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THE NUTRITIONAL VALUE OF OYSTERS AND OTHER SEA FOOD*

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AVAILABLE INFORMATION regarding the nutritive value of shellfish, such as oysters, clams, crabs, lobsters, and shrimp, is very meager notwithstanding the importance of this class of food in the diet of man since prehistoric times. Oysters constitute the most valuable fishery product of the United States. It has been estimated that the annual yield in this country is about 18,350,000 bushels, with a return to the fishermen of nearly thirteen million dollars.

Shellfish as a source of food presents several interesting features. Land crops that furnish us with food, such as grains, fruit, vegetables, and indirectly, animal products, derive their nourishment from the more limited confines of the soil and the atmosphere, while the shellfish that are harvested from the "boundless deep" are constantly bathed by that universal solvent which supplies every element that is required for the growth of a living organism. Shellfish contain relatively large amounts of mineral constituents. The human body has many elements the significance of which are as yet unknown. Much progress has been made during recent years in studying the part played in nutrition by calcium, phosphorus, iodine, iron and other elements and their relation to such diseases as rickets, goiter and anaemia. It is not improbable that research in the near future will reveal equally important and specific functions in physiological processes for such elements as copper, manganese, arsenic, cobalt, nickel and others which are even now claimed to be normal constituents of animal and plant tissue. Sea food contains all of these elements collected from that vast chemical storehouse—the ocean.

It has been estimated [1] that one pound of oysters, equivalent to about one pint per day, will furnish approximately 35 per cent of the calcium, 53 per cent of the phosphorus, and 136 per cent of the iron required in the food of an average person daily. According to analyses made in the U. S. Bureau of Fisheries,[2] oysters, clams, and lobsters contain about 200 times as much iodine as milk, eggs, or beefsteak. The importance of foods containing relatively large amounts of iodine is emphasized by the relation that has been discovered between deficiency of iodine in foods and drinking water, and the prevalence of goiter and cretinism.

POOR SOURCES OF FATS AND CARBOHYDRATES

Shellfish are not rich sources of fats and carbohydrates, although they are not lacking in these dietary factors. The edible portions of mollusks and crustaceans range in their fat content from 1 to 2 per cent. Unlike most other types of

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animal food they contain carbohydrate in the form of glycogen, sometimes called "animal starch." The quantity ranges from 1 to 5 per cent. The other two dietary factors, proteins and vitamins, are well represented in the edible portions of shellfish.

Aside from the importance of oysters as an extensively used item of food, their vitamin content has an additional point of interest connected with the general question of the origin of vitamins. It is well established that animal life is dependent upon the vegetable world for its source of vitamins, with the exception of vitamin D. The material upon which oysters feed consists largely of diatoms and minute organisms, marine forms of life to which has been traced the origin of vitamin A, found so abundantly in certain fish liver oils, such as that of the cod. Small marine animals feed on these vegetable organisms, and store the vitamins in their tissues. These lower forms of animal life become a prey for larger species, which successively pass on the vitamin, until it is found in such fish as the cod, herring, and haddock.

On account of the very limited knowledge available regarding the vitamin content of sea food, work was started in the Bureau of Chemistry to obtain more information regarding the nutritive value of shellfish from the standpoint of their vitamin content and of the nutritive quality of their proteins. Our work has yielded data concerning vitamins in oysters, and the proteins in oysters, clams, and shrimp. The work is still in progress.

Results thus far obtained show that oysters are a good source of vitamins A and B. Clams do not appear to be as good a source of vitamin B, while on the other hand the crude proteins of clams have given better results than have those of oysters.

The proteins of shrimp have also been studied, both chemically and by feeding experiments. The amino acid content of the muscle of shrimp is not differentiated from that of the muscle of higher animals by any marked variations. The feeding experiments have shown that the proteins of shrimp muscle are of good nutritive character.

VITAMIN CONTENT OF OYSTERS

Randoin[3] has previously reported that oysters contain vitamin C, the antiscorbutic vitamin. We have found that they also contain vitamins A and B.

Two feeding methods are in general use for testing substances for vitamins, the prophylactic method and the curative method. For the determination of vitamin B in oysters we used both methods. The results obtained by the one method served as a check on those obtained by the other.

In the first experiments with oysters, we used a product that was prepared by dehydrating fresh oysters at a low temperature, not over 45° C., and at reduced atmospheric pressure. During this process some chemical change took place which rendered the product so distasteful to the animals that only in a relatively few cases were we able to get them to eat the required experimental quantities of the oyster. We, therefore, had to resort to some other method, which, without impairment to its vitamin properties, would yield a product having uniform composition, and which was both palatable and could be satisfactorily weighed out in the desired quantities. This was accomplished by grinding fresh oysters in a frozen condition. It has been shown[4] that freezing temperatures have no appreciable effect on vitamins. Suitable quantities of the frozen product were then weighed and fed to the rats daily, apart from the rest of their diet.

VITAMIN B IN OYSTERS

In the tests carried out by the prophylactic method for estimating vitamin B in oysters, young albino rats weighing from 45 to 50 grams were fed a basal diet containing adequate quantities of all of the food factors required for the normal

growth of rats, with the exception of vitamin B. This diet was composed of an intimate mixture having the following composition:

Casein (vitamin B-free)	20	parts
Inorganic salt mixture (Osborne and Mendel)	5	"
Butter fat	15	"
Starch	60	"

Separate from this ration there was given additionally each day the portion of oysters which was being tested.

We started out with 3.5 grams of frozen oysters daily. Rats will make but little or no growth, and can live but a short time, on a ration lacking in vitamin B, such as the basal ration used. The animals that received 3.5 grams of oysters grew at a very satisfactory rate for about sixty days. After that their rate of growth was more or less retarded.

With 2 grams of oysters daily the animals grew at a fair rate for about three weeks. For the next 60 days they barely maintained their weight. When 1 gram of oysters was given, growth at a slower rate during the first 2 or 3 weeks resulted followed by a decided decline in weight.

These results show that 3.5 grams of fresh oysters daily is *nearly,* but not quite, sufficient to provide the necessary amount of vitamin B for the normal growth of young rats. Oysters apparently contain a very significant amount of vitamin B.

It is of interest to compare the results obtained by the prophylactic method with those obtained by the curative method. In the latter case, the animals received only the basal diet until positive indications of vitamin B deficiency were apparent, such as loss of weight and general manifestations of malnutrition. Then, the animals were given daily 5 grams of oysters. The almost immediate response shown by resumption of growth was marked and their subsequent rate of growth was excellent.

Even 3.5 grams of oyster daily enabled the animals to respond as promptly as did those that received 5 gram portions, but the subsequent rate of growth was not quite as rapid, and at the end of about 35 days there was a tendency for a slight retardation of growth.

When the amount of oyster given daily was reduced to 2 grams, decline in weight was arrested and growth at even a fair rate in some cases followed for three weeks or more.

The results obtained by these two methods for estimating vitamin B in oysters, the curative method and the prophylactic method, agree well. They show that 3.5 grams of raw oyster given daily just falls short of providing enough vitamin B to meet the growth requirements of rats.

The frozen oysters as fed in these experiments contained 84 per cent of water. When the various quantities used, namely, 5, 3.5, and 2 grams, are calculated to a moisture free basis, they represent respectively 0.8, 0.56, and 0.32 grams of dry oysters. On this basis, oysters compare favorably as a source of vitamin B with foods which are recognized as excellent sources of this dietary factor.

VITAMIN A IN OYSTERS

As a criterion for estimating vitamin A, we have used the method of finding out the effectiveness of different quantities of oyster for curing xerophthalmia that had developed as a result of feeding rats a diet deficient in this vitamin. After unmistakable symptoms of xerophthalmia were manifest, the value of different quanties of the oyster for curing the eye affliction was determined by feeding different groups of animals daily portions of 3.5, 2, and 1 grams of the frozen oyster. The vitamin A-free basal ration had the following composition:

Casein (Vitamin A-free)	20	parts
Salt mixture (Osborne and Mendel)	5	"
Crisco	15	"
Starch	60	"

Vitamin B was supplied to each animal by 0.4 gram of yeast given daily, apart from the basal ration.

The animals receiving 3.5 grams of oysters showed, in most cases, rapid improvement in the condition of their eyes as well as in their rate of growth. The

time required for restoration of their eyes to normal condition varied somewhat with the severity of the ophthalmia. With the exception of two or three cases where the disease had progressed to such a degree that their eyes were irreparably damaged, the animals were cured in most instances in about ten days.

Two gram daily portions of the oysters also enabled the animals to recover from xerophthalmia about as soon as did the 3.5 gram portions. Their resumption of growth, however, was at a much slower rate. One gram of oysters had but little, if any, curative effect.

Work is in progress on the estimation of vitamin D, the antirachitic vitamin, but thus far we have not secured sufficient data to justify the drawing of any conclusions.

PROTEINS

In order to get more or less comparable results on the nutritive values of the proteins of oysters, clams, and shrimp, as judged from their capacity to promote growth, the different substances tested were incorporated in the diets in such quantities that they would furnish about 9 per cent of crude protein. The protein content of the product tested was calculated by multiplying the nitrogen percentage by the factor 6.25. This is a rather low intake level of protein in the diet, and is about the minimum on which young rats will grow satisfactorily even on proteins of the best quality. By using a low percentage of protein in the diet, it is easier to detect small deficiencies in the nutritive properties of a protein.

PROTEINS OF OYSTERS

For the estimation of the growth-promoting value of the proteins of oysters, fresh, shelled oysters were heated to coagulate the proteins, drained, and dried in a current of warm air. They were then ground to a meal. The material thus prepared contained 47.8 per cent of crude protein. It was incorporated in the ration as the sole source of protein, with the exception of a negligible quantity contained in the small amount of yeast which was given to furnish vitamin B. The composition of the ration is shown in Table I. On this ration, young rats weighing from 46 to 51 grams at the start of the experiment, grew very uniformly for as long as 7 months, although at a rather slow rate. There are several factors which I will not have time to dwell upon, that must be taken into consideration when interpreting the results of these experiments. Were it possible to make allowances for these factors there is but little doubt that the growth promoting value of the oyster proteins would show up better than the results obtained indicate.

TABLE I

COMPOSITION OF THE RATIONS

	Oyster diet	*Clam diet*	*Shrimp diet*
Dried oyster	18.8	....	....
Dried clam	....	15.8	....
Dried shrimp	....	....	9.63
Salt mixture	5.0	5.0	5.00
Crisco	20.0	20.0	20.00
Starch	56.2	59.2	65.37

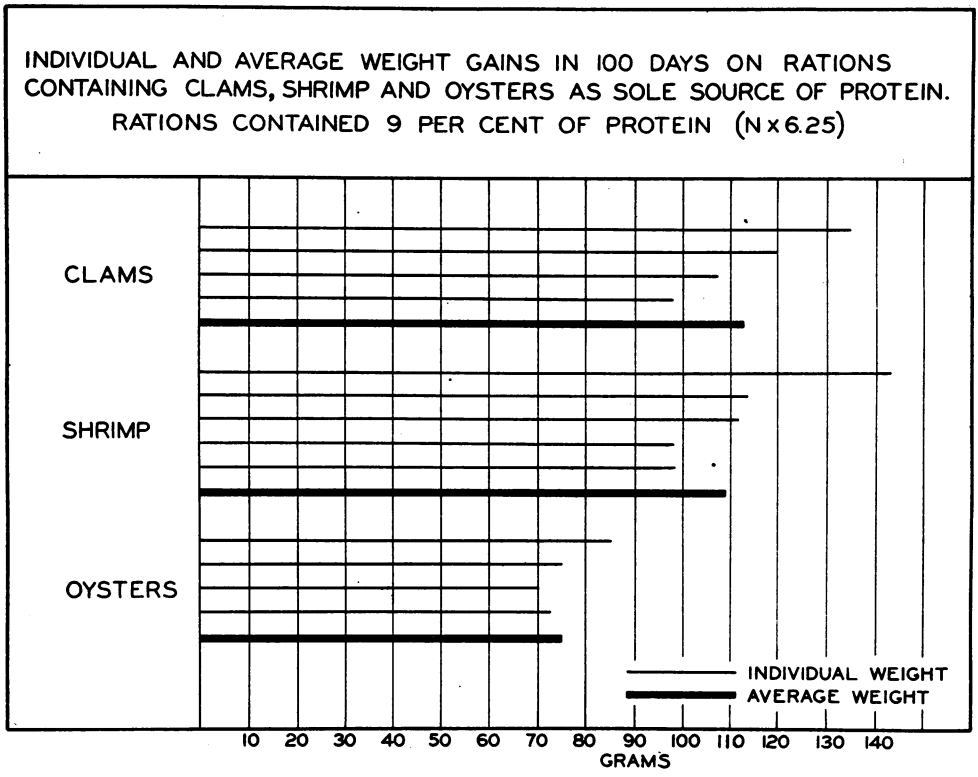
0.2 gram of yeast and 0.3 gram of cod liver oil were given daily to supply vitamins.

PROTEINS OF CLAMS

Hard shell clams, also known as quahaugs, were prepared for the feeding tests in the same way as the oysters, and the tests carried on in the same manner. For 170 days the animals grew on this ration at a quite satisfactory rate, approximating in some cases what may be considered a normal rate.

PROTEINS OF SHRIMP

Studies to determine the nutritive quality of the proteins of shrimp were carried on both chemically[5] and biologically. We were enabled to do this because the muscle, the edible portion of the shrimp, after having been extracted with alcohol and ether, consists of a white, fibrous substance, composed almost entirely of protein. It was possible, therefore, to submit this product to the usual procedures uses in protein analysis for estimating amino acids. The results of these analyses (Table II) show that shrimp muscle contains relatively high percentages of those amino acids known



to be indispensable for the normal nutrition of animals. From these figures it could be predicted with a fair degree of assurance that shrimp muscle contains protein of satisfactory nutritive quality. These expectations were later substantiated by the results obtained from feeding experiments.

TABLE II

PERCENTAGES OF SOME AMINO ACIDS IN SHRIMP MUSCLES

	Per cent
Cystine	1.78
Arginine	10.24
Histidine	3.78
Lysine	7.60
Tryptophane	1.21
Tyrosine	4.88
Aspartic acid	6.98
Glutamic acid	15.00

For the feeding experiments, fresh shrimp muscle was dried and ground to a meal. A ration containing a quantity of the shrimp meal representing 9 per cent of protein (Table I) enabled animals to grow for over 18 weeks at a very good rate.

Chart I shows the comparative gains in weight of rats fed the oyster, clam, and shrimp rations during the first 15 weeks of the feeding experiments. As indicated, there was but very little difference in the rate of growth of the animals receiving the clam and shrimp rations, while those receiving the oyster ration gained only a little over two-thirds as much.

For obtaining further data for comparing the growth-promoting value of the proteins of the three types of sea food studied, figures were calculated showing the ratio between the gain in weight and the amount of protein consumed during a fixed period. Record was kept of the total food consumption for each rat during the period of the experiment. The amount of nitrogen in the food consumed multiplied by the factor 6.25 gave the figure for the crude protein. It was found that for every gram of oyster pro-

tein eaten during a six weeks' period the animals gained in weight 1.27 grams. Similarly, the ratio obtained for clam protein was 2.05, and 2.15 for shrimp protein. This method of comparing the efficiency of different proteins for growth was first used by Osborne and Mendel.[6]

Further work is in progress for estimating the nutritive value of these shellfish from a more comprehensive standpoint than merely their capacity to promote growth in young animals.

The results of the experiments above described show that, judged from the criterion of growth promotion, the proteins of clams, shrimp, and oysters compare favorably with the proteins of other articles that are highly regarded for their nutritive value.

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THE MEDICAL CONSULTANT IN INDUSTRY AND HIS VALUE TO THE STATE*

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THE EVER INCREASING number of industries in this state, once an agricultural commonwealth, brings a change in the factors which concern the health and welfare of its people.

While there is little doubt that "a bold peasantry is its country's pride," yet the road to apparent economic security appears to-day to be shorter through industrialism, with its constant and certain hours of labor, its activity, excitement, shelter from the changing elements of nature, its opportunity for greater comradeship among the workers, and the certainty of one day of rest in seven; having a greater fascination for the men and women of our day and age, much stronger than agriculture may offer.

The change from an agricultural commonwealth to one of industry has shown its greatest strides during the past generation, or quarter-century. In 1880 there were in the State of New York 241,000 farms. In 1900 there were 226,000 and in 1920, 193,000 farms, or a decrease of 33,000 farms, a number greater than the total number of farms in the State of Massachusetts in 1920.

In 1900 there were 35,000 factories in New York State, and in 1926 the total had increased to 65,000, while the wage earners of the manufacturing and mechanical industries for the same period were respectively 755,000 and 1,764,000, exclusive of personnel, managers, salesmen, truckmen, clerks, etc.

While the generation span through which we have just passed has been preeminently one of science, and industry

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